



# Earthworm Diversity in Trans-Gangetic Habitats of Haryana, India

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## Abstract

The status of earthworm biodiversity in Transgangetic plains of Eastern Haryana, (longitude 76° 27' 30" E to 77° 36' 40" E and latitude 29° 10' 25" N to 30° 32' 55" N) India has been assessed. A total of 285 different sites covering cultivated, wasteland, garden, grassland and sewage in rural, urban and sub-urban localities were surveyed. A total nine taxa of earthworms, namely *Amyntas morrisi*, *Amyntas robustus*, *Lampito mauritii*, *Metaphire posthuma*, *Eutyphoeus incommodus*, *Eutyphoeus waltoni*, *Eutyphoeus nicholsoni*, *Octocheatona beatrix* and *Drawida nepalensis* belonging to six genera and three families were recorded in the study area constituting 2.15 per cent of total Indian earthworm fauna. Of these nine taxa reported, three are exotic peregrine and remaining six are endemic peregrine. Out of nine, six species have been reported for most of the sampling sites (*L. mauritii*, *M. posthuma*, *E. incommodus*, *E. waltoni* and *D. Nepalensis*) while remaining three (*A. morrisi*, *A. robustus*, *E. nicholsoni*, and *O. Beatrix*) were limited to some specific sites in studied regions of Haryana. Earthworm diversity has been influenced directly by microclimatic factors and anthropogenic activities. Positive correlation has been observed with organic carbon, total nitrogen and moisture content. The preference for physico-chemical conditions of soil and food quality affects the distribution of earthworms in a particular area. This study contributes first hand information on earthworm fauna of the transgangetic planes and likely to add more native species to the existing ones, which are very important for vermicomposting process.

**Keywords:** Diversity, earthworm, Eastern Haryana, India, transgangetic plains.

## Introduction

The soil is a valuable bio-resource that inhabits million of micro and macro organisms involved in biodegradation and soil building processes. In addition to micro-organisms the macrofauna particularly earthworms play significant role in decomposition of organic waste and humus formation. These megadrile fauna have been considered as the soil ecosystem engineers<sup>1</sup>. There were 20 families and nearly 4200 species distributed all over the world<sup>2</sup>. India has a rich diversity of earthworms inhabiting 418 species. The earthworm fauna of India is dominant mainly by indigenous species constituting approximately 89% of total earthworm diversity<sup>2</sup>.

India has wide Latitudinal range (between 8° 4' – 37° 6' N) as well as complex topography responsible for diverse climate. It include temperate to arctic in the Himalayan and tropical in the peninsular region. India has been classified into 15 broad agro-climatic zones. This division is considered enough for the evaluation of earthworm diversity<sup>3</sup>. Julka also divided five earthworm diversity zones in India viz., mega diversity, high diversity, medium diversity, low diversity and poor diversity zones. Composition and population structure of the earthworm has been directly affected by different land use pattern in various agro climatic regions of the country<sup>4-5</sup>. Both exotic peregrine and native peregrine species have been found tolerable to disturbed conditions. In subtropical as well as tropical regions, there is wide species variation rather than species richness<sup>6</sup>.

Comprehensive taxonomic and distribution survey of Oligochaeta particularly of earthworms was done by many researcher<sup>7-9</sup>. The publication of papers<sup>2,10,11</sup> fill the much needed gap in taxonomic and distribution studies which can be taken as the most recent.

The earthworm fauna of Haryana is very poorly studied only five species of five genera belonging to two families have been recorded by Jit (unpublished). Despite varied habitat, good moisture content and intensive farming there have been fewer studies on earthworm diversity in Transgangetic habitats in Haryana of India; still wide scope exists for the presence of more earthworm species which are yet to be described. The present work involves a survey of earthworms in transgangetic plains of Haryana which is a second largest food grain producing state of India. Therefore an attempt has been made to conduct a survey of earthworm species available in the selected habitats of Transgangetic plains to record both exotic and native species to add and validate existing literature on earthworm diversity and richness.

## Methodology

**Study area:** An extensive survey was conducted between 2012-2013 in diverse habitats of Transgangetic plains (Karnal, Yamunanagar, Panipat, Ambala and Kurukshetra), of India. Agriculture area in Haryana (latitude 30.30° North and longitude 74.60° East) is classified into 3 zones i.e., dry sub humid, semi

arid and arid. Present study area falls under semi arid zone. The state is covered by Uttar Pradesh in the east and Punjab in the west. Himachal Pradesh and Shivalik hills lies in its north whereas Rajasthan and Aravalli hills in the south. Yamuna is the only major river passing through this state, having a very good network of canals. It is the needed impetus for earthworm diversity and agriculture, the mainstay of Haryana's economy. The altitude of Haryana varies between 700 ft to 900ft above the sea level with mean annual rainfall 70-125 cm.

**Sampling:** Earthworms were collected by digging soil monolith with a shovel or spade (50x50x25cm). Soil lumps were broken and silted to collect the earthworms. These worms along with soil samples were brought to the laboratory in poly bags. Samples were taken from different pedo-ecosystem (sewage, garden grassland, cultivated and waste lands) from Trans - gangetic plains. The number of each earthworm species recorded per square meter was categorized as abundant (>20), moderate (10-20), poor (<10). The ecological categories of earthworm species were also recorded. The physiochemical properties of soils from each sampling site were also analyzed to establish the possible species habitat relationship.

**Preservation:** Collected worms were sacrificed using in 70% ethyl alcohol. Immediately these worms were transferred to a flat bottomed container for fixation in 5-10% formalin for 24 hour. Thereafter the fixed earthworms were stored in suitable size vials or bottles filled with 70% ethyl alcohol or 5-10% formalin. A label with locality name, date and collector's name was added to each vial. It is essential to keep the worms straight because curled and twisted specimens are difficult to handle during dissection. Both morphological and anatomical characteristics are important for taxonomy of earthworms. Earthworms were identified to the species level with the help of monographs of many researcher<sup>8,9,11</sup>. The identification of all the collected species were confirmed by Dr. R. Paliwal ZSI, Solan (H.P). Body colour and pigmentation of worms were recorded.

**Ecological indices calculations:** During random survey some habitats were selected and ecological indices were calculated. Diversity index ( $H' = \sum p_i \ln p_i$ ) where  $p_i = n_i / N$ , species dominance [ $C = \sum (p_i)^2$ ], species richness ( $d = S - 1 / \ln N$  where S is the total no. of species) and evenness ( $e = H' / \ln S$ ) were calculated for some selected pedoecosystems during random survey by standard methods<sup>12-15</sup>. Correlation between earthworm density and physicochemical factors was also studied by using Pearson's correlation coefficient (r).

**Soil analysis:** Soil samples from each site were taken for analysis. pH (1:5w/v) and temperature (10 cm depth) of collected soil was determined by using pH meter (Systronics System) and soil thermometer, respectively. Moisture content was also estimated gravimetrically on a wet weight basis by

oven drying (105°C). Organic carbon and total nitrogen were analyzed using<sup>16-17</sup>.

## Results and Discussion

During the present investigation, a total of nine species of earthworm's viz. *Amyntas morrisoni* (Beddard), *Amyntas robustus* (Beddard), *Lampito mauritii* Kinberg, *Metaphire posthuma* (Vaillant), *Eutyphoeus incommodus* (Beddard), *Eutyphoeus waltoni* Michaelsen, *Eutyphoeus nicholsoni* (Beddard), *Octocheatona beatrix* (Beddard) and *Drawida nepalensis* Michaelsen, belonging to six genera and three families of Oligochaeta were identified from various habitats of the surveyed areas of Transgangetic plains of Haryana, India table 1. The present result revealed that family Octochaetidae and Megascolicidae are dominating earthworm fauna in this region. Maximum earthworm species were recorded in Karnal (longitude 76° 29' 54" E to 77° 13' 45" E and latitude 29° 26' 29" N to 29° 59' 38"N) of Eastern Haryana followed by Yamunanagar (longitude 77° 4' 0" E to 77° 35' 30" E latitude 29° 56' 0" N to 30° 29' 30" N). Out of nine, five species (*E. incommodus*, *E. waltoni*, *D. nepalensis*, *A. morrisoni*, *A. robustus*) were reported firstly from the various sites of eastern Haryana. The fauna of *E. incommodus*, *E. waltoni*, *D. nepalensis* and *O. beatrix* were also recorded from some regions of western Himalayas and Uttarpradesh<sup>2,18</sup>. Whereas *M. posthuma* and *L. mauritii* are widely distributed earthworm in the surveyed region strongly support the earlier reports from various agro-ecosystem of India<sup>19-20</sup>. The distribution of a species and its conspicuous absence in a particular locality depicts earthworm diversity in various pedoecosystem. Similar relationships have also studied by earlier workers<sup>18,20,21</sup> showing species composition of earthworms in various pedoecosystem.

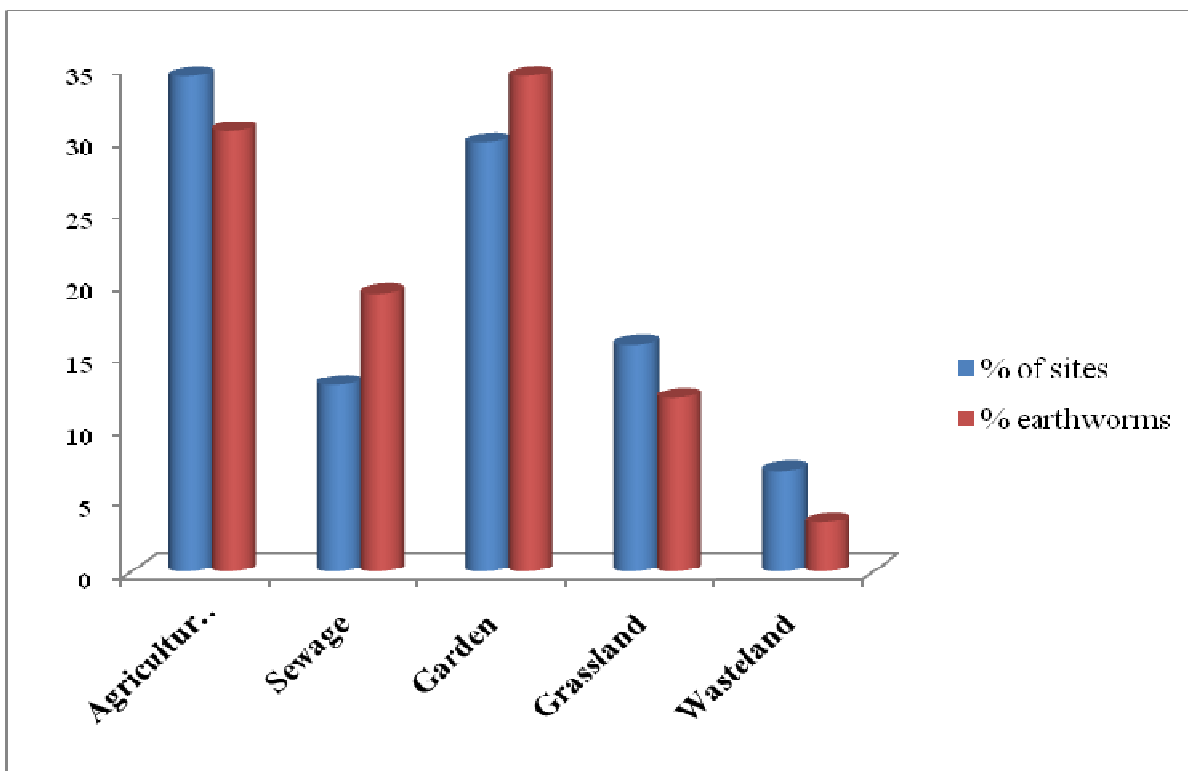
Out of nine recorded species of earthworm, six (i.e., *Lampito mauritii*, *Eutyphoeus incommodus*, *Eutyphoeus waltoni*, *Eutyphoeus nicholsoni*, *Octocheatona beatrix* and *Drawida nepalensis*) are native peregrine for this region table1. No endemic worm was recorded during the study period from this region. Major earthworm species recorded during the survey was found to be native peregrine. Earthworm distribution pattern has been reviewed by Julka<sup>3</sup> in various agro-ecological zones of India suggesting no evidence for endemic earthworm in the area. However, two endemic species (*Barogaster barodensis* and *Eudichogaster prashadi*) have been identified from Gujarat, India. Most of the presently known species are peregrine in various regions of the world<sup>22</sup>. These species can tolerate extreme soil environment conditions and are the predominant earthworm fauna in tropical ecosystems<sup>23</sup>. The overall observation of the study is that the study area as a whole has a predominance of native earthworm species which is positive indication that the area is not severely disturbed, as evidence by the presence of more native than exotic species. Similar observations were given by Julka<sup>24</sup> who has claimed that the Indian earthworm fauna is dominated by native species, forming 89% of the total earthworm diversity.

The distribution pattern of the different regions of eastern Haryana of India is given in figure 1 and figure 2. *L. mauritii* was very common in the surveyed areas constituting nearly 24.8% of the total earthworm samples followed by *M. posthuma* (23.2%), *E. incommudus* (19.3%), *E. waltoni* (16.0%) and *D. nepalensis* (8.9%). Remaining species exhibited restricted distribution pattern in the studied area. Earthworm diversity was comparatively poor in this region indicating that life supporting system for their dispersal and survival is not much available. Earthworms have been recorded from residential areas,

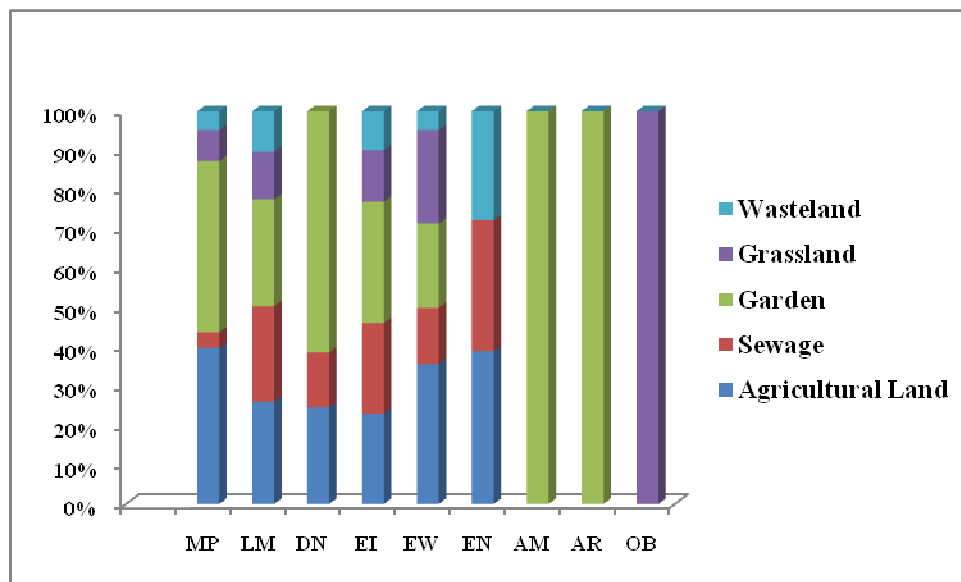
agricultural fields, urban gardens, manmade canal, domestic waste water drains, nurseries etc. Maximum earthworm population in studied soils suggest the suitability of a particular area for earthworm survival. The earthworm species *L. mauritii*, *M. posthuma*, and *E. incommudus* occurred in maximum habitats and were categorized as abundant as well as highly adaptive species for this region table 2. It suggests that local climatic conditions are favourable for these species whereas some showed restricted distribution patterns like *A. morrissi*, and *A. robustus* in garden and *O. beatrix* in grassland only.

**Table 1**  
**Earthworms recorded during present survey in four district of Eastern Haryana**

Family/earthworm species	Category	District wise distribution
<b>I MEGASCOLECIDAE</b>		
1. <i>Amyntas morrissi</i> (Beddard)	Exotic peregrine	Karnal
2. <i>Amyntas robustus</i> ( Beddard)	Exotic peregrine	Karnal
3. <i>Metaphire posthuma</i> (Vaillant)	Exotic peregrine	Karnal, Yamunanagar, Kurukshetra, Ambala
4. <i>Lampito mauritii</i> Kinberg	Native peregrine	Karnal, Yamunanagar, Kurukshetra, Ambala
<b>II MONOLIGASTRIDAE</b>		
5. <i>Drawida nepalensis</i> Michaelsen	Native peregrine	Karnal
<b>III. OCTOCHAETIDAE</b>		
6. <i>Eutyphoeus incommodus</i> (Beddard)	Native peregrine	Karnal, Panipat, Yamunanagar, Kurukshetra, Ambala
7. <i>Eutyphoeus waltoni</i> Michaelsen	Native peregrine	Karnal, Panipat, Yamunanagar
8. <i>Eutyphoeus nicholsoni</i> (Beddard)	Native peregrine	Yamunanagar
9. <i>Octochaetona beatrix</i> (Beddard)	Native peregrine	Karnal



**Figure1**  
**Distribution of earthworms in different habitats of Transgangetic region of Haryana, India**



**Figure 2**  
**% age frequency of different earthworm species in various habitats**

The study of ecological indices provides information regarding diversity and richness of particular ecosystem. The diversity index was found to be higher and ranged from 1.495 at grassland to 0.691 at wasteland. The higher value of index showed higher species diversity in their habitat. The species richness (d) index provides evidence for preference of a particular biological community in an area. Margalef species richness ranged from 0.20 at wasteland to 0.75 at agricultural field. Whereas Pielous evenness ranged from 0.1 at wasteland to 0.23 at grassland site table 3. Most of the studies on earthworm diversity reported the presence of 2 to 5 species at any one location<sup>23, 25</sup>. During the survey period maximum of 6 and 5 species were recorded from agriculture field and grassland, respectively. Shannon diversity index for habitats; Agricultural field (1.195), grassland (1.495), garden (1.336) and sewage (1.014) clearly suggesting that these habitats are suitable for earthworm inhabitation and colonization in the region. Two species *L. mauritii* and *E. incommodus* were found in wasteland with species diversity index of 0.691 and index of dominant was 0.50. They showed shared dominance in this habitat. Species evenness (e) and diversity index was higher at grassland. This showed that this habitat has greater species diversity and abundant food and suitable physico-chemical factors compared to other site. Similar results were shown by Tripathi and Bhardwaj<sup>19</sup> who reported higher diversity indices and evenness in cultivated soil whereas Najar and Khan<sup>26</sup> reported the same from vegetable garden soil.

Ecological category and eco-morphological characteristics of earthworm species of transgangetic region of Haryana are given in table 4. Among recorded species *A. morrissi* and *A. robustus* are epi-aneic while *M. posthuma* comes under endo-aneic category. *L. mauritii* was only the aneic worm found during the survey period. Rests of the five species are endogeic. This

showed that the soil layers of more than 30 cm deep were not suitable for propagation of earthworms. The earthworm fauna of eastern Haryana may be endogeic, epi-aneic, endo-aneic or aneic in nature.

The physico-chemical characteristics of soils in different habitats are given in table 5. pH of soil ranged between 6.5- 8.3 for different habitats. Moisture content ranged between 5.21-25.6% during the study. The soil temperature is also important factor affecting the soil moisture. The soil temperature ranged between 23.0-38.0°C whereas Organic Carbon ranged between 0.09-1.47%. The total nitrogen content ranged between 0.01 and 0.19 % in different habitats. The range of C: N ratio was 2.01 to 11.77 in earthworm inhabitation soils. The results revealed that habitat preference of earthworm may be affected by the soil physico-chemical properties. Each habitat of this region was mainly comprised of coarse and fine loamy soil. The correlation studies showed that soil moisture, organic carbon and total nitrogen was found to be significantly correlated with the distribution of the worms (p<0.001). No significant correlation was observed between worm density and temperature as well as pH. This is in agreement with various studies carried out in different parts of India<sup>21,27,28</sup>. pH of soil in this region varied from slightly neutral to alkaline (7-8). This shows alkalophilous nature of earthworm fauna in the recorded region. Edwards and Lofty<sup>29</sup> have suggested that earthworm were tolerant to narrow pH range, very few being restricted to highly acidic soil (pH <4). The pH values recorded in the present study are within the range established for the distribution of earthworms. Some habitats showed a narrow range of soil temperature (like gardens and nurseries) while others showed drastic variation (wastelands, agricultural fields etc). Wide range of soil temperature in different habitats with high earthworm population suggests its adaptability in the region. Moreover the

earthworm movement to deep soil is another mode of adaptation against temperature variation. Land use pattern have changed the development of agricultural practices for the last few years in the region of Haryana. Ghabbour<sup>30</sup> in their studies concluded that region population of earthworm increases as a result of new irrigated sandy soil in Egypt. They found that modification in

terrestrial habitats by irrigation provide successful colonization of soil fauna. The habitat preferences of the earthworm were positively correlated with the availability of food resources and soil moisture. Since earthworm show cutaneous respiration for this, water availability in the soil act as key factor for earthworm dispersal in terrestrial ecosystems.

**Table 2**  
**Relative abundance of earthworm fauna in major sampling habitats and their characteristics in Eastern Haryana**

Earthworm habitat and no. of sites	Characteristics	Species									
		Am	Ar	Mp	Lm	Dn	Ei	Ew	En	Ob	
1. Cultivated land	Standing crops (sugarcane fields, rice fields, Jowar field orchards, turmeric fields etc.)	-	-	+++	+++	++	+++	++	+++	-	
2. Waste lands	Waste land in city and town around railway stations public parks schools near about villages etc. Lands not being used for agriculture.	-	-	+	+++	-	+++	+	-	-	
3. Grassland	Grass covering public parks, lawns etc.	-	-	++	+++	-	+++	++	-	++	
4. Garden	Home garden, kitchen garden, parks, garden at public places like school, university, railway stations etc. Nurseries, leaf litter covers, under tree plantations	+	+	+++	+++	+++	+++	+	-	-	
5. Sewage	Moist soil around waste water drains, house level waste water collection channels, waste water collection sites near the drinking water resources like, hand pumps, water tanks etc.	-	-	+	+++	+	+++	+	++	-	

+ present (<10); ++ moderate (10-20); +++ abundance (>20); - absent, (Am) *A. morrissi*; (Ar) *A. robustus*; (Lm) *L.mauritii*; (Mp) *M. posthuma*; (Ei) *E. incommodus*; (Ew) *E. waltoni*; (En) *E. nicholsoni*; (Ob) *O. beatrix* and (Dn) *D. nepalensis*

**Table 3**  
**Ecological indices for earthworm fauna in Transgangetic region of India**

Habitat	Ecological Index				
	Number of species	Shannon diversity (H)	Dominance (c)	Richness (d)	Evenness (e)
Agricultural field	6	1.195	0.189	0.753	0.180
Wasteland	2	0.691	0.500	0.200	0.140
Grassland	5	1.495	0.247	0.615	0.229
Garden	4	1.336	0.273	0.450	0.200
Sewage	3	1.014	0.383	0.335	0.169

**Table 4**  
**Eco-morphological characteristics with ecological categories of earthworms of Haryana, India**

Species	Pigment	Length (mm)	Diameter (mm)	No. of segments	Fresh Mass (g)	Ecological categories
<i>A. morrissi</i>	Reddish brown	71-142	3.8-4.6	115-135	1.12	Epi-aneic
<i>A. robustus</i>	Dark reddish brown	170 -350	7.2-8.1	184-206	2.7	Epi-aneic
<i>M. posthuma</i>	Brown	65-135	3.8-5.0	95-130	1.06	Endo- aneic
<i>L. mauritii</i>	Unpigmented	71-145	3.3-4.7	86-165	0.77	Aneic
<i>E. incommodus</i>	Pink	42-95	2.0-4.0	75-89	0.45	Endogeic
<i>E. waltoni</i>	Grey	80-150	0.9-1.3	71-90	0.54	Endogeic
<i>E. nicolsoni</i>	Pink	37-105	1.8-3.7	71-84	0.51	Endogeic
<i>O. Beatrix</i>	Unpigmented	52-90	2.0-3.9	55-125	0.48	Endogeic
<i>D. nepalensis</i>	Purple greyish	86-128	3.0-4.2	93-140	0.43	Endogeic

**Table 5**  
**Distribution of nine species of earthworm in relation to physo-chemical properties**

Species	Habitat	% moisture	pH	Temp(°C)	OM (%)	OC (%)	TN (%)
<i>M.posthuma</i> , <i>L. mauritii</i> , <i>D. nepalensis</i> <i>E.incommodus</i> , <i>E. waltoni</i> , <i>E. nicolsoni</i>	Cultivated Land	5.35-23.80	6.5-7.8	25-35	1.02-2.34	0.58-1.36	0.11-0.15
<i>L. mauritii</i> , <i>E.incommodus</i> , <i>E. waltoni</i> ,	Wasteland	5.21-16.60	7.0-7.8	32-38	0.24-1.72	0.14-0.99	0.07-0.19
<i>M.posthuma</i> , <i>L. mauritii</i> , <i>E.incommodus</i> , <i>E. waltoni</i> , <i>O. Beatrix</i>	Grassland	8.08-21.60	7.5-8.0	25-35	0.16-1.82	0.09-1.06	0.01-0.09
<i>A. robustus</i> <i>A. morrisi</i> <i>M. posthuma</i> , <i>L. mauritii</i> , <i>D. nepalensis</i> <i>E.incommodus</i> , <i>E. waltoni</i> ,	Garden	9.08-25.60	6.5-8.3	23-30	0.16-2.54	0.09-1.47	0.03-0.16
<i>M.posthuma</i> , <i>L. mauritii</i> , <i>D. nepalensis</i> <i>E.incommodus</i> , <i>E. waltoni</i> , <i>E. nicolsoni</i>	Sewage	12.60-33.80	7.0-8.0	22-30	0.41-3.39	0.24-1.97	0.03-0.21

## Conclusion

It becomes evident from the present study that the transgangetic plains of Haryana have rich diversity of endemic earthworms. Some species showed a patchy dispersion pattern like *A. robustus*, *A. morrisi*, and *O. Beatrix*. Moreover their distribution was not uniform in local soils. The present results revealed the occurrence of nine species in only some restricted habitats / sites which are approximately double the earlier record. The poor diversity in Panipat district may be due to industrial areas which may affect the distribution of earthworms. The fauna of earthworms in the vicinity of pond was very rare since the edges of ponds had concrete or clay soils it was difficult for earthworm to make burrows and ingest soil. The succession of intensive agriculture practices and manmade canal system in the region successfully promotes colonization of earthworm communities. Although, species number indicates their richness in local soils which may be very important for vermicomposting process.

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